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General Papers

Publication Productivity of the Technical Physics and Prototype Engineering Division at Bhabha Atomic Research Centre

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ABSTRACT

This scientrometric study analyses the publications of Technical Physics and Prototype Engineering Division at Bhabha Atomic Research Centre. There were 704 research papers published during 1986-2006 scattered in diverse domains like crystals (192), thin films (173), glasses and ceramics (102), instrumentation (66), and miscellaneous (171). The highest number of publications (80) was in the year 2006. The average number of publications per year was 33.52. The most prolific authors were: S.K. Gupta (215), G.P. Kothiyal (171), S.C. Sabharwal (151), D.K. Aswal (139), V.C. Sahni (105), K.P. Muthe (101), J.V. Yakhmi (94) publications. The journals preferred for publishing were: *Physica C* (37), *Journal of Crystal Growth* (30), *Physical Review B* (28), *Pramana* (16), and *Bulletin of Indian Vacuum Society* (12). Collaboration trend was multi-authored publications. There were more than 94 per cent multi-authored publications. Publication concentration was 3.04 and publication density was 3.68.

Keywords: Technical physics, prototype engineering, scientometrics, bibliometrics, institutional studies, Bhabha Atomic Research Centre, publication productivity, authorship pattern, collaboration rate, activity index, author productivity, channels of communication, Bradford distribution, publication concentration, publication density

1. INTRODUCTION

Technical Physics and Prototype Engineering Division (TPPED), formerly known as Technical Physics Division is one of the oldest divisions of Bhabha Atomic Research Centre (BARC), which has contributed a lot to the indigenous development of a variety of devices, materials systems and instruments that are required for successful implementation of atomic energy programmes in India. The division was also involved in the transfer of technology and commercialisation of these efforts to institutions like IBP, Electronic Corporation of India Limited (ECIL), Bharat Electronics Limited (BEL), and Kamal Engineering, etc. It has also supplied and commissioned the large vacuum system for space simulation chamber (for the Department of Space) and for coating of large mirrors for optical telescope of Indian Institute of Astrophysics at Kavalur. It has also supplied a variety of indigenously fabricated mass spectrometers and related components to different Department of Atomic Energy (DAE) units like Heavy Water Plants and spent-fuel reprocessing facilities were a few examples to mention. Among the more challenging tasks undertaken recently are the design and assembly of beamlines for INDUS-1 and INDUS-2. The main thrust areas of the division in which R & D is involved are detectors, crystals, gas sensors, glass/glass-ceramics, glass-to-metals and ceramic-to-metal seals, synchrotron instrumentation, UHV-based surface analytical instruments, superconductivity, organic/polymer/nano phase thin films, and molecular devices.

The term "Naukometriya" (the Russian for "Scientometrics") was coined by the Russian Statistician Nalimov, Adler and Granovsky[1] for the quantitative methods of studying the development of science. Pritchard[2] used the term "Bibliometrics" for "all studies, which seek to quantify the process of written communications". He described bibiliometrics as "the applications of mathematical methods to books and other media of communication". Narin[3] used the term "evaluative bibliometrics" to denote the use of bibliometric techniques, especially publication and citation analysis in the assessment of scientific activity. Kademani and Vijai Kumar[4-5] have discussed various bibliometric, scientometric concepts used for evaluation.

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Over the years scientometric and bibliometric techniques have become tools to evaluate the productivity of research institutes, individual researcher and to map the growth of subject. Publication and citation counts are being extensively used for evaluation purpose of an institute. Guay[6] studied the quantitative survey of the emergence of organic chemistry research in India during 1907-1926 covered by *Chemical Abstracts*. Chemists who were conducting research in India were separated into three distinct groups, on the basis of their cultural identity and educational background. Important disparities between these groups have been stated, both in terms of research fields and publication outlets. Klaic[7] carried out the analysis of 2018 papers published during 1976-1985 by the chemists from the Rugjer Boškovi Institute (Yugoslavia). Both publications and citation counts were used for the analysis. Kim and Kim[8] examined research performance of Chemists during 1992-98 at Chemistry Department, Seol National University, Korea. A total of 651 papers published by the 29 faculty members were considered. Both publication and citation counts were used for the study. No correlation was found between the number of papers by a particular chemist and the average number of citations per paper for that chemist. Kannappanavar, Swamy and Vijay Kumar[9] have studied the authorship trend and collaborative research in chemistry in India during 1996-2000 and reported the trend towards multi-authorship papers. Kademani, *et al*.[10] have carried out the scientometric analysis of 1733 papers published during 1970-1999 by the chemists from the Chemistry Division of BARC in various domains of chemistry. They have studied year-wise publication productivity, collaboration trend, author productivity and Lotka's law, the most productive authors, use of communication channels by the chemists and country-wise distribution of journals. A citation analysis of publications of Chemistry Division of BARC was also carried out by Kademani, *et al*.[11] This paper dealt in detail the extent of citations received, time lag of citations, domainwise distribution of citations, citation lifecycle of highly cited papers, citing documents etc. Kademani, *et. al*.[12-14] have analysed the publication productivity of Bioorganic Division of BARC consisting of 475 papers published during 1972-2002, 724 papers published by Analytical Chemistry Division, BARC during 1972-2003 and 1044 papers published by Radiochemistry Division of BARC during 1958-2005. Vinkler[15] has also studied the bibliometric analysis of publication activity of a scientific research institute. Many scientometric studies have appeared in the literature to focus on the performance of science in various domains[16-29].

2. OBJECTIVES

Main objective of this paper is to quantitatively document the publication behaviour of scientists of TPPE Division at BARC, and

(i) to find out the publication productivity,

(ii) to find out domain-wise research productivity,

(iii) to find out domain-wise Activity Index,

(iv) to ascertain the authorship and collaboration pattern of researchers,

(v) to identify the most prolific authors and author productivity,

(vi) to identify the types of communication channels used by the scientists,

(vii) to find out country-wise distribution of journals,

(viii) to find out distribution of journals as per impact factor, and

(ix) to document keywords from titles of the papers.

3. MATERIALS AND METHODS

Scientometric analysis of 704 publications by the scientists of TPPED published during 1986-2006 was done, which formed the basic data for this study. The publications from the Vacuum Physics and Instrumentation Division (VPID) and Mechanical Design and Prototype Development Section (MDPDS), which have split from TPPED are not included for the present study.

All the bibliometric details of publications in hardcopy form were scanned and all the data elements were transferred to spread sheet application. After validation, the data was analysed as per the objectives of the study. The bibliographic fields were analysed by normal count procedure. Full credit was given to each author regardless of whether he happens to be the first author or the last author. Similarly, one score was allotted to subject, journal and keyword.

4. RESULTS AND DISCUSSION

4.1 Growth of Publications

This paper traces the growth of publications of TPPED, BARC since 1986-2006. During these 21 years, a total of 704 publications were published. The highest number of publications was 80 in 2006. The average number of publications per year was 33.52. Figure 1 gives year-wise publication productivity trend of TPPED. Figure 2 gives growth rate of publications in different three-year blocks. During 1986-1988 the growth rate of the publications of TPPED was very low and in the years 1992-1997 no exponential growth was observed. Thereafter, during 1998-2000 the growth rate of the publications was highest of all the years of the publications. After that, there was a gradual decrease in the growth rate in the subsequent three-year blocks of 2001-2003 and 2004-2006.

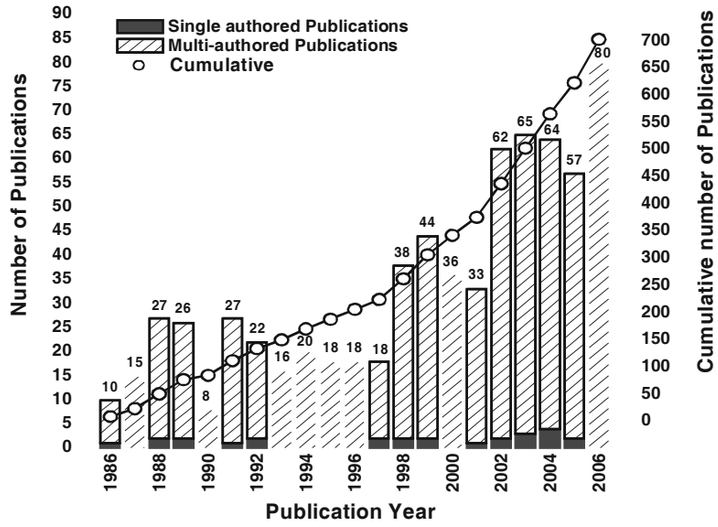


Figure 1. Year-wise distribution of publications of TPPED.

4.2 Domain-wise Contributions

During 21 years (1986-2006) TPPED has contributed significantly to the following domains:

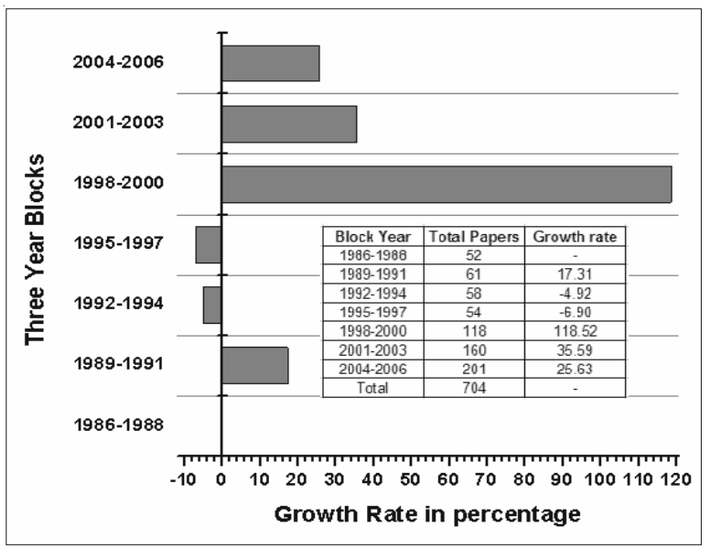
- Thin Films
- Crystals
- Instrumentation
- Glasses and Ceramics, and
- Miscellaneous domains.

There were 192 publications in Crystals followed by 173 publications in Thin Films, 102 publications in Glasses and Ceramics, and 66 publications in Instrumentation. One hundred and seventy one publications of TPPED could not be categorised in any of the above categories, have been grouped in miscellaneous domains. Domain-wise publication trend is presented in Figures 3(a) to 3(f).

The highest numbers of publications were 28 in Glasses and Ceramics in 2006 followed by 20 publications in Thin Films in 2003, 20 publications in Crystals in 1998, 17 publications each in miscellaneous domains in 2004 and 2006, and 10 publications in Instrumentation in 1999.

4.3 Domain-wise Activity Index

The activity index (AI) characterises the relative research efforts of a country in a given subject[19]. Karki,



Block Year	Total Papers	Growth rate
1986-1988	52	-
1989-1991	61	17.31
1992-1994	58	-4.92
1995-1997	54	-6.90
1998-2000	118	118.52
2001-2003	160	35.59
2004-2006	201	25.63
Total	704	-

Figure 2. Publication growth of TPPED in three-year blocks during 1986-2006.

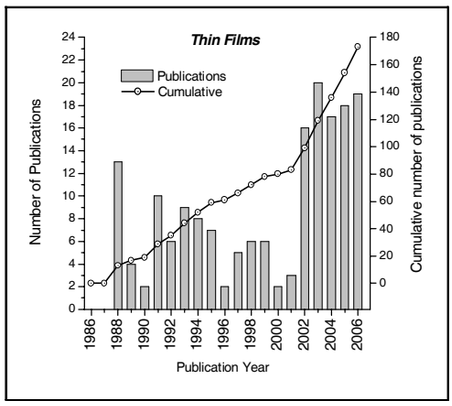


Figure 3(a). Publication trend in thin films.

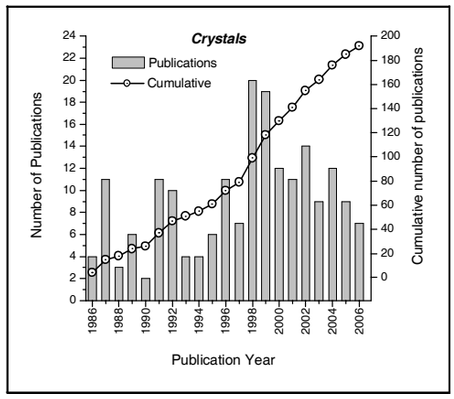


Figure 3(b). Publication trend in crystals.

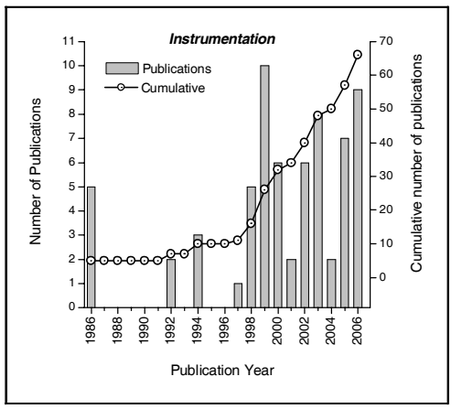


Figure 3(c). Publication trend in instrumentation.

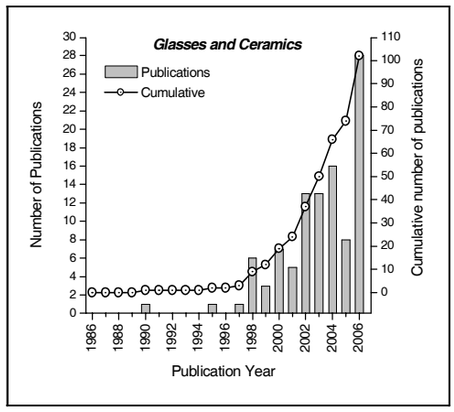


Figure 3(d). Publication trend in glasses and ceramics.

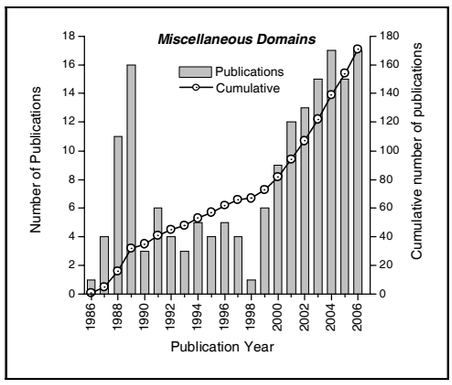


Figure 3(e). Publication trend in miscellaneous domains.

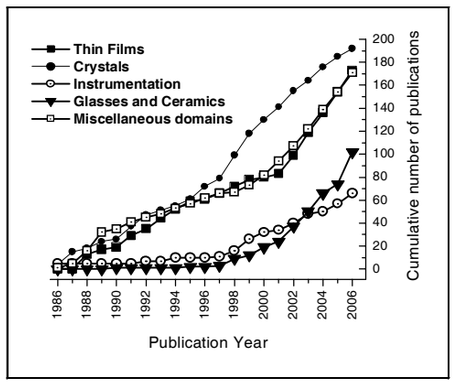


Figure 3(f). Domain-wise cumulative growth of publications.

et al. have used this AI for studying activity and growth of organic chemistry in India[18]. In the present context, AI for TPPED has been calculated for seven different three-year blocks in various domains to see how TPPED performance changed during different periods and the priorities shifted in different domains by using the Karki, *et. al*'s formula in a modified way. Here AI is calculated as follows:

$$\frac{P}{Q} * \frac{M}{N} * 100$$

where

P = Number of publications in a domain during the particular block of period

Q = Total number of publications in a domain during the whole period of study

M = Total number of publications during the whole period of study, and

N = Total number of publications produced during the particular block of period.

The AI for TPPED was calculated and plotted (Fig. 4). It is clearly depicted in the Fig. 4 that how the research efforts were devoted to various domains during seven different three-year blocks by the TPPED. In the first block (1986-1988) maximum emphasis was given to Crystals followed by Miscellaneous domains and Instrumentation while in the second block (1989-1991) emphasis was shifted to miscellaneous, and crystals domains respectively.

In the third block (1992-1994) the stress was laid on Thin Films followed by Crystals and Instrumentation. In the fourth block (1995-1997) the thrust was on Crystals followed by Thin Films. In fifth block (1998-2000) emphasis was given to Instrumentation followed by Crystals. In the sixth block (2001-2003) the stress was given to Glasses and Ceramics followed by Instrumentation. Also in seventh block the maximum emphasis was on Glasses and Ceramics followed by Thin Films. Domain-wise publications and Activity in different three-year blocks is given in Table 1 and Fig. 4.

4.4 Domain-wise Authorship Pattern

Domain-wise authorship pattern and number of publications in each domain is presented in Table 2 and overall authorship pattern in Fig. 5. Authorship trend is towards multi-authorship papers. Four authored (125) papers account for 17.76 per cent followed by five authored papers (121) with 17.19 per cent, six authored papers (98) with 13.92 per cent, three authored papers (76) with 10.80 per cent and seven authored papers (70) with 9.94 per cent. There is one paper each with sixteen authors in domains Crystals and Instrumentation indicating the multidisciplinary and collaborative nature of research activity. Only 26 (3.69) publications were single-authored. Abt[17] has concluded that single-authored papers will decrease in frequency in coming years, but will not become extinct.

4.5 Most Prolific Authors and Author Productivity

The prolific authors and their publications are listed for the period 1986-2006 only. The author's publications prior to 1986 are not taken into consideration. The most prolific authors were: S.K. Gupta (1986-2006) who topped the list with 215 publications followed by G. P. Kothiyal (1986-2006) with 171 publications, S.C. Sabharwal (1986-2006) with 151 publications, D.K. Aswal (1988-2006) with 139 publications, V.C. Sahni (1991-2006) with 105 publications, K.P. Muthe (1988-2006) with 101

Table 1. Domain-wise activity index in different three-year blocks

Three-Year Blocks	Domain-wise Publications and Activity Index					Total
	A	B	C	D	E	
1986-1988	13 (101.73)	18 (126.92)	5 (102.56)	0 (0.00)	16 (126.68)	52
1989-1991	16 (106.74)	19 (114.21)	0 (0.00)	1 (11.31)	25 (168.73)	61
1992-1994	23 (161.37)	18 (113.79)	5 (91.95)	5 (0.00)	12 (85.18)	58
1995-1997	14 (105.50)	24 (162.96)	1 (19.75)	2 (25.56)	13 (99.11)	54
1998-2000	14 (48.28)	51 (158.47)	21 (189.83)	16 (93.59)	16 (55.82)	118
2001-2003	39 (99.19)	34 (77.92)	16 (106.67)	31 (133.73)	40 (102.92)	160
2004-2006	54 (109.33)	28 (51.08)	28 (95.52)	52 (178.56)	49 (100.36)	201
Total	173 (100)	192 (100)	66 (100)	102 (100)	171 (100)	704

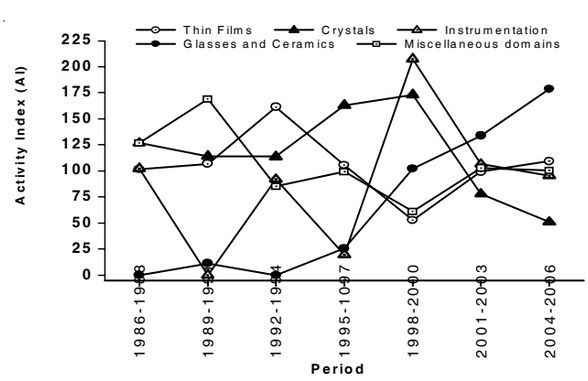


Figure 4. Domain-wise activity index in different three year blocks.

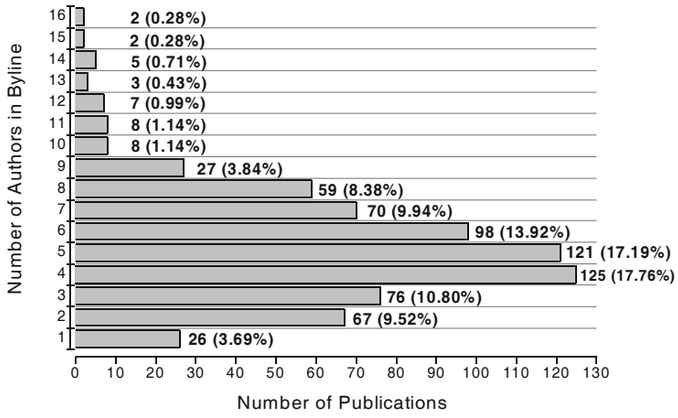


Figure 5. Authorship pattern in the publications of TPPED.

publications, J.V. Yakhmi (2001-2006) with 94 publications, S.C. Gadkari (1986-2006) with 88 publications, V.K. Shrikhande (1990-2006) with 85 publications, M.K. Gupta (1986-1997) and G. Ravikumar (1986-2006) with 81 publications each, Sangeeta (1987-2006) with 78 publications, Madhumita Goswami (2000-2006) with 48 publications, Shahwati Sen (1997-2006) with 47 publications, J.C. Vyas (1986-2006) with 45 publications, Ajay Singh (2000-2006) with 43 publications, A.K. Grover (collaborator from TIFR) (1988-2006) and V.R. Katti (1988-2006) with 38 publications each, A.K. Debnath (1991-2006) with 37 publications, D. Sahoo (1986-2005) with 35 publications, and P.K. Mishra (1987-2003) and R.V. Srikantiah (1986-2000) with 34 publications each. Table 3 provides a list of authors who have contributed more than five publications. It shows the productivity of scientists

Table 2. Number of papers having domain-wise authorship pattern during 1986-2006

Papers with no. of authors	Domains					Total	Percentage
	A	B	C	D	E		
One	5	6	1	3	11	26	3.69
Two	5	25	3	1	33	67	9.52
Three	7	27	6	10	26	76	10.80
Four	23	45	12	26	19	125	17.76
Five	30	32	14	18	27	121	17.19
Six	34	10	11	19	24	98	13.92
Seven	26	9	7	16	12	70	9.94
Eight	18	15	3	6	17	59	8.38
Nine	15	5	2	3	2	27	3.84
Ten	3	2	3	0	0	8	1.14
Eleven	3	3	2	0	0	8	1.14
Twelve	4	3	0	0	0	7	0.99
Thirteen	0	3	0	0	0	3	0.43
Fourteen	0	4	1	0	0	5	0.71
Fifteen	0	2	0	0	0	2	0.28
Sixteen	0	1	1	0	0	2	0.28
Total	173	192	66	102	171	704	100.00
Percentage	24.57	27.27	9.38	14.49	24.29	100.00	-

(A-Thin Films; B-Crystals; C-Instrumentation; D- Glasses and Ceramics and E-Miscellaneous)

and their associations with the Division during the period under study as far as scientific publications are concerned. The authors with * indicates the collaborators other than TPPED who have published collaborative papers with TPPED during the period 1986-2006.

4.6 Preference of Channels of Communications by Scientists

The publications of TPPED are spread over various channels of communications as shown in Fig. 6. Out of the 704 publications, 367 were published in conferences followed by 328 in journals, 5 as reports, and 2 publications each as patents and books.

4.7 Preference of Journals for Communication by Scientists

The publications (328) of TPPED in various journals are spread over 89 journals. The leading journals preferred by the scientists of TPPED were *Physica C* with 37 papers, *Journal of Crystal Growth* with 30 papers, *Physical Review B* with 28 papers, *Pramana-Journal of Physics* with 16 papers, *Bulletin of Indian Vacuum Society* and *Solid State Physics (India)* with 12 papers each, *Applied Physics Letters* with 9 papers, *Bulletin of Materials Science* and *Superconductor Science and Technology* with 8 papers each, *Sensors and Actuators B, Thin Solid Films* and *Indian Journal of Pure and*

Table 3. Highly productive authors and collaborators of TPPED, BARC during 1986-2006

Author	No. of Publications	FPY-LPY	Total Years	Paper/year
Gupta, S. K.	215	1986-2006	21	10.24
Kothiyal, G. P.	171	1986-2006	21	8.14
Sabharwal, S. C.	151	1986-2006	21	7.19
Aswal, D. K.	139	1988-2006	19	7.32
Sahni, V. C.	105	1991-2006	16	6.56
Muthe, K. P.	101	1988-2006	19	5.32
Yakhmi, J. V.	94	2001-2006	6	15.67
Gadkari, S. C.	88	1986-2006	21	4.19
Shrikhande, V. K.	85	1990-2006	17	5
Gupta, M. K.	81	1986-1997	12	6.75
Ravikumar, G	81	1986-2006	21	3.86
Sangeeta	78	1987-2006	20	3.9
Goswami, Madhumita	48	2000-2006	7	6.86
Sen, Shashawati	47	1997-2006	10	4.7
Vyas, J. C.	45	1986-2006	21	2.14
Singh, Ajay	43	2000-2006	7	6.14
Grover, A. K.*	38	1988-2006	19	2
Katti, V. R.	38	1988-2006	19	2
Debnath, A. K	37	1991-2006	16	2.31
Sahoo, D	35	1986-2005	20	1.75
Mishra, P. K.	34	1987-2003	17	2
Srikantiah, R. V.	34	1986-2000	15	2.27
Hayakawa, Y*	30	1998-2001	4	7.5
Kumagawa, M*	30	1998-2001	4	7.5
Rao, T.V. Chandrasekhar	29	1991-2006	16	1.81
Bhattacharya, S*	28	1996-2006	11	2.55
Kaur, Manmeet	28	2000-2006	7	4
Ramakrishnan, S*	27	1995-2006	12	2.25
Gupta, L.C.*	23	1988-2005	18	1.28
Joshi, Niraj	23	2002-2006	5	4.6
Kulshreshtha, S.K.*	23	1998-2006	9	2.56
Sarkar, A	23	2000-2006	7	3.29
Sudarsan, V *	23	1998-2006	9	2.56
Bhushan, K.G.	22	1998-2006	9	2.44
Chaddah, P *	22	1986-1991	6	3.67
Jagannath,	22	2000-2006	7	3.14
Manikandan, Shobha	22	2000-2006	7	3.14
Mirza, T	21	1987-2002	16	1.31
Prasad, R	21	1988-2005	18	1.17
Gandhi, D.P.	20	1988-1999	12	1.67
Banerjee, S.S.*	17	1996-2001	6	2.83
Chowdhury, P	16	1998-2006	9	1.78
Desai, D.G	16	1989-2006	18	0.89

Higgins, M.J. *	15	1998-2006	9	1.67
Saxena, Vibha	15	2003-2006	4	3.75
Shinmura, M*	15	1998-2000	3	5
Vishwanadham, C.S*	15	1999-2006	8	1.88
Bhandarkar, V.B.	14	2002-2006	5	2.8
Chauhan, A.K.	14	1993-2004	12	1.17
Deshpande, S.K.*	14	2003-2006	4	3.5
Sawant, B.B.	14	1997-2004	8	1.75
Sharma, B.I.	14	2003-2005	3	4.67
Ghosh, B	13	1986-1995	10	1.3
Shah, K.V.	13	2001-2006	6	2.17
Thinaharan, C	13	2002-2006	5	2.6
Tiwari, Babita	13	2001-2006	6	2.17
Goswami, G.L.*	12	1999-2006	8	1.5
Kannan, S*	12	2003-2005	3	4
Kulkarni, M.S.*	12	2003-2005	3	4
Kumar, Rakesh*	12	2003-2006	4	3
Mishra, D.R. *	12	2003-2005	3	4
Bhattacharya, P*	11	1986-1988	3	3.67
Karandikar, S.C.	11	1987-1997	11	1
Korgaonkar, A.V.	11	1992-2005	14	0.79
Kupfer, H*	11	2002-2005	4	2.75
Lee, Sung-Ik*	11	2002-2004	3	3.67
Singh, K.D. *	11	1988-1997	10	1.1
Tomy, C.V.*	11	1996-2002	7	1.57
Balakrishnan, G*	10	1996-2002	7	1.43
BaLani, S.J.	10	1986-2005	20	0.5
Heber, O*	10	1999-2005	7	1.43
Narang, Savita N	10	1995-1999	5	2
Paul, D Mck*	10	1996-2002	7	1.43
Pinto, R *	10	1995-2006	12	0.83
Roy, M *	10	2003-2006	4	2.5
Sangiri, A.K.	10	1995-2006	12	0.83
Singh, M.R.	10	1989-2006	18	0.56
Zajfman, D*	10	1999-2005	7	1.43
Kim, Heon-Jung*	9	2002-2004	3	3
Mori, T*	9	1999-2001	3	3
Patil, N.G.	9	1996-2001	6	1.5
Rappaport, M.L.*	9	1999-2005	7	1.29
Wagh Pradip Anandrao*	9	1998-2006	9	1
Ahuja M.N.	8	1991-1997	7	1.14
Alstein N*	8	1999-2000	2	4
Bhagwat K.V.	8	1989-2003	15	0.53
Choi Eun-Mi*	8	2002-2004	3	2.67
Choudhury Shipra*	8	2002-2006	5	1.6
Joshi, M.R.	8	1997-2002	6	1.33
Kadam, R.M.*	8	2000-2006	7	1.14
Lee, Hyun-Sook*	8	2002-2004	3	2.67
Sinha, S.K.	8	1989-2003	15	0.53
Tyagi, A.K.*	8	1997-2006	10	0.8
Betty, C.A.*	7	1991-2006	16	0.44
Bhattacharya, Shovit	7	2003-2006	4	1.75
Ghosh, K*	7	1995-1996	2	3.5
Jogad, M.S.	7	2000-2006	7	1
Kang, W.N.*	7	2002-2004	3	2.33
Keshawani, K.S.	7	1991-1997	7	1
Ray, A	7	1996-2006	11	0.64

Senthil Kumar, M*	7	2005-2006	2	3.5
Bhattacharya, D*	6	1995-2006	12	0.5
Bhide, M.K.*	6	2000-2005	6	1
Dasannacharya, B.A.*	6	1987-1990	4	1.5
Dixit, Anupam*	6	2006-2006	1	6
Dua, A.K.*	6	2000-2003	4	1.5
Hong, S.C.*	6	1986-1987	2	3
Kim Kijoon, H.P.*	6	2002-2004	3	2
Koiry, S.P.	6	2005-2006	2	3
Koyama, T*	6	1999-2000	2	3
Phadnis, S.V.*	6	1995-2005	11	0.55
Salunke, H.G.	6	1992-2000	9	0.67
Shetty, H.J.*	6	1986-1992	7	0.86
Wolf, Th*	6	2002-2004	3	2
Acharyulu, G.V.S.G.	5	1991-2001	11	0.45
Chandra, Girish*	5	1995-1996	2	2.5
Goyal, P.S.*	5	2000-2006	7	0.71
Jha, S.N.*	5	2001-2005	5	1
Malik, M.K.*	5	1987-1990	4	1.25
Menon, G.I.*	5	1996-2001	6	0.83
Padma, N	5	2005-2006	2	2.5
Pedersen, H.B.	5	2000-2000	1	5
Purandare, S.C.*	5	1991-2000	10	0.5
Raj, P*	5	1994-2006	13	0.38
Sastry, M.D.*	5	2000-2002	3	1.67
Sengupta, P*	5	2003-2006	4	1.25
Shidruk, B.S.*	5	1997-2002	6	0.83
Sutar, Dayanand	5	2005-2006	2	2.5
Verma, S.L.	5	2000-2003	4	1.25
Zhukov, A.A.*	5	2002-2004	3	1.67

*(FPY: First Publication Year; LPY: Last Publication Years; and *- Collaborators from other Divisions/Organisations)*

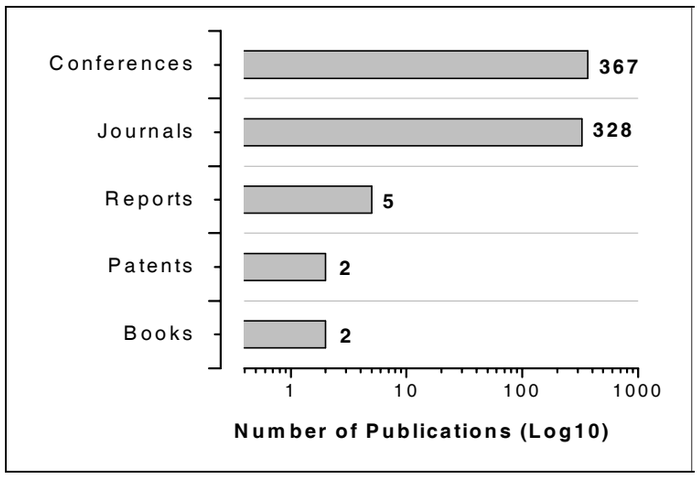


Figure 6. Distribution of publications of TPPED in various types of channels of communications.

Applied Physics with 7 papers each, *Journal of Applied Physics* with 6 papers and *Journal of Physics: Condensed Matter, Review of Scientific Instruments* and *Solid State Communications* with 5 papers each. Table 4 and Fig. 7 give journal-wise publications of papers. Publication density is defined as the ratio of the total number of papers published to the total number of journals in which the papers were published and publication concentration as the ratio in percentage of the journals containing half of the papers published to the total number of journals in which those papers were published during the period under study. The publication concentration[15] observed in present study is 3.04 and publication density is 3.68.

Table 4. Journals preferred for publishing articles by the scientists of TPPED during 1986-2006

Sl. No.	Journal Title	No. of papers	Cumulative	Impact Factor 2005	Country
1	*Physica C*	37	37	0.948	Netherlands
2	*J. Cryst. Growth*	30	67	1.681	Netherlands
3	*Phys. Rev.- B*	28	95	3.185	USA
4	*Pramana*	16	111	0.38	India
5	*Bull. Ind. Vacuum Soc.*	12	123	NA	India
6	*Solid St. Phys. (India)*	12	135	NA	India
7	*Appl. Phys. Lett.*	9	144	4.127	USA
8	*Bull. Mater. Sci.*	8	152	0.777	India
9	*Superconductor Sci. & Tech.*	8	160	1.896	England
10	*Sensors & Actu.- B*	7	167	2.646	Switzerland
11	*Thin Solid Films*	7	174	1.569	Switzerland
12	*Ind. J. Pure & Appl. Phys.*	7	181	0.495	India
13	*J. Appl. Phys.*	6	187	2.498	USA
14	*J. Phys.: Cond. Matter*	5	192	2.145	England
15	*Rev. Sci. Instr.*	5	197	1.235	USA
16	*Solid St. Comm.*	5	202	1.489	England
17	*Asian J. of Phys.*	4	206	NA	India
18	*BARC News Letter*	4	210	NA	India
19	*Cryst. Res. and Tech.*	4	214	0.833	Germany
20	*J. Lumines.*	4	218	1.518	Netherlands
21	*Phys. St. Solidi –A*	4	222	1.041	Germany
22	*Phys. Rev. A*	4	226	2.997	USA
23	*Solid St. Phys.*	4	230	6.25	USA
24	*Appl. Sur. Sci.*	3	233	1.263	Netherlands
25	*Bull. Res. Inst. of Electron.*	3	236	NA	Japan
26	*Curr. Sci.*	3	239	0.728	India
27	*J. Med. Phys.*	3	242	NA	India
28	*Key Eng. Mater.*	3	245	0.224	Suisse
29	*Mater. Lett.*	3	248	1.299	Netherlands
30	*Phase Trans.*	3	251	0.671	England
31	*Phys. B*	3	254	0.796	Netherlands
32	*Phys. Rev. Lett.*	3	257	7.489	USA
33-46	*14 journals with 2 papers*	28	285	NA	-
47-89	*44 journals with 1 papers*	43	328	NA	-

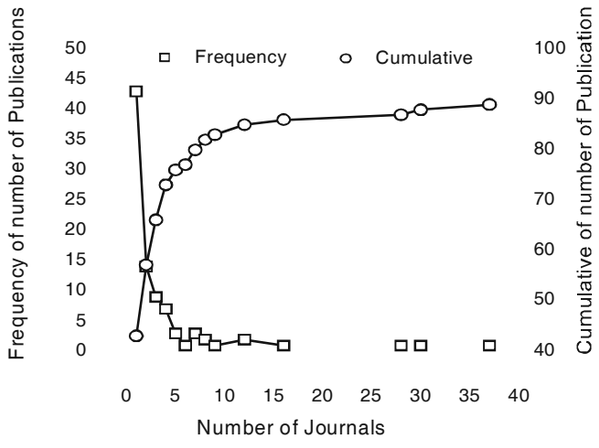


Figure 7. Bradford-Zipf bibliograph of distribution of journals used for publications.

4.8 Country-wise Distribution of Journals

There were 346 journals spread over 20 countries. Table 6 gives country-wise distribution of journals and publications. USA has published 725 publications in 116 journals followed by England 310 publications in 71 journals, Netherlands 359 publications in 56 journals, Germany 56 publications in 29 journals, India 216 publications in 27 journals, and Switzerland 52 publications in 14 journals.

4.9 Impact Factor-wise Distribution of Journals and Publications

Figure 8 provides the distribution of publications in journals as per their impact factors (IF). The publications were published in the journals with IF ranging from 0.01 to 10.00. More than 21 percent of the publications were published in the journals with impact factors ranging from 0.51 to 1.00. About 15 percent of the publications were published in the journals which are not covered by *Science Citation Index- Journal Citation Report* -2005.

4.10 Country-wise Distribution of Journals

Journals most preferred for publication of papers were from the Netherlands with 91 (27.74 per cent) publications followed by India 79 (24.09 per cent), USA with 75 (22.87 per cent) publications, England with 44 (13.41 per cent) publications and Switzerland with 19 (5.79 per cent) publications. Figure 9 gives the country-wise distribution of journals and publications.

4.11 Documentation of Keywords Appeared in the Titles of the Papers

Title of a publication conveys the thought contents of the paper. The potency of information concentrated on the title of the paper is more than the rest of the sections of the paper. Therefore, if a word occurs more frequently than expected, it reflects the emphasis given by the authors about the research field of their interest. The important words called 'keywords' are one of the best indicators to understand and grasp instantaneously the thought content of the papers, methodologies used and areas of

Table 6. Country-wise distribution of journals publishing articles in Neutron Scattering

Country	Journals	Percentage	Publications	Percentage
USA	116	33.53	725	40.30
England	71	20.52	310	17.23
Netherlands	56	16.18	359	19.96
Germany	29	8.38	56	3.11
India	27	7.80	216	12.01
Switzerland	14	4.05	52	2.89
France	7	2.02	23	1.28
Japan	7	2.02	13	0.72
Singapore	6	1.73	25	1.39
Israel	2	0.58	2	0.11
Poland	2	0.58	7	0.39
Austria	1	0.29	1	0.06
Canada	1	0.29	1	0.06
Czech-Republic	1	0.29	1	0.06
Ireland	1	0.29	1	0.06
Peoples-R-China	1	0.29	1	0.06
Slovakia	1	0.29	1	0.06
South Korea	1	0.29	3	0.17
UAE	1	0.29	1	0.06
Ukraine	1	0.29	1	0.06
Total	346	100	1799	100

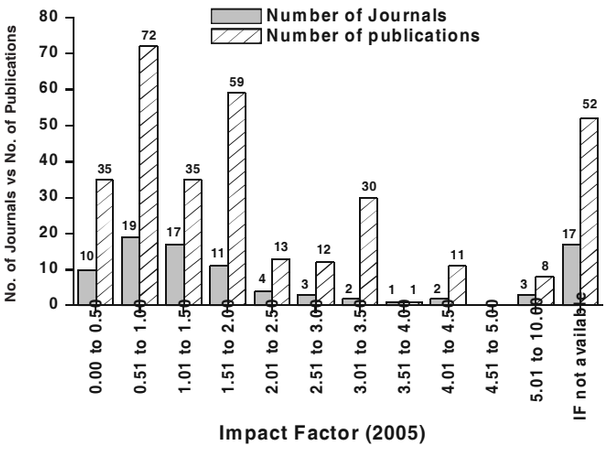


Figure 8. Impact factor-wise distribution of journals and publications.

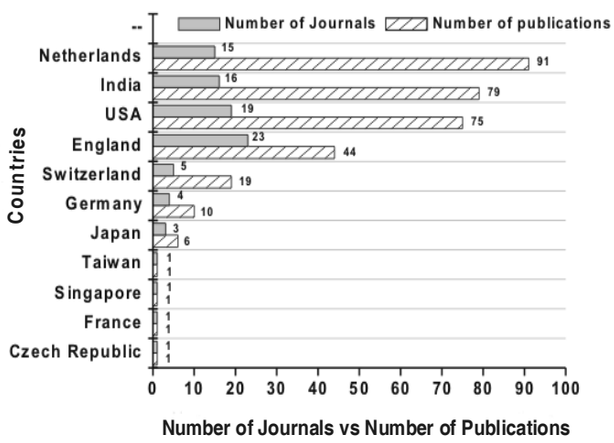


Figure 9. Country-wise distribution of journals and publications.

research addressed to. The high frequency keywords were: glasses (62), sintering (42), $YBa_2Cu_{3-x}Co_xO_z$ (39), glass ceramics (38), crystals (30), molecular beam epitaxy (25), detectors (24), crystallization (23), MgB_2 (20), and Supercooling (20). Table 5 gives a list of high frequency keywords appeared more than five times.

5. CONCLUSION

This study tried to highlight quantitatively the contributions made by the scientists of TPPED at BARC during 1986-2006. The analysis showed that the TPPED has produced 704 publications in diverse areas of

Table 5. Keywords with frequency more than five appeared in TPPED publications

Keywords	Frequency
Glasses	62
Sintering	42
$YBa_2Cu_{3-x}Co_xO_z$	39
Glass ceramics	38
Crystals	30
Molecular beam epitaxy	25
Detectors	24
Crystallization	23
MgB_2	20
Supercooling	20
$Bi_2Sr_2CaCu_2O_x$	17
Growth	17
Silicon Crystals	17
Superconducting energy gaps	17
Hydrogen sulphide	15
Peak effect regime	15
Crystal Growth	14
Fabrication	14
High Tc superconductors	14
High temperature superconductors	14

Keywords	Frequency
Optical absorption	7
Polycrystalline substrates	7
Room temperature activation	7
Seal applications	7
SnO_2:CuO	7
SnO_2:Pd	7
Sputtering system	7
Thermophysical properties	7
Vortex Lattice	7
$Y_xNd_{1-x}Ba_2Cu_3O_z$	7
Ag/Al	6
Al	6
Ammonia sensing	6
Bilayers	6
CdTe	6
Dielectric studies	6
Disorder	6
LiB_3O_5	6
Microhardness	6
Nanocrystalline	6

Lead silicate	14	NMR studies	6
Magnetization	14	Phase transition	6
Metastability	14	Phosphate	6
Thin film deposition	14	Plane	6
2H-$NbSe_2$	13	Sensing	6
Critical current	13	Sensors	6
Deposition	13	Solution Growth	6
Gas sensing	13	Structural Studies	6
$La_{1-x}Pb_xMnO_3$	13	Substrate temperature	6
Luminescence	13	Temperature	6
Shock Induction	13	Template	6
Single crystals	13	Thermoelectric generator	6
Magnesium aluminium silicate	12	Wires	6
Dissipation	11	BBO	5
Optical properties	11	Bi-Sr-Ca-Cu-O	5
Thick crystals	11	CuO	5
X-ray photoelectron Spectroscopy	11	Degradation	5
$YBa_2Cu_30_7$	11	Dosimetry	5
Anisotropy	10	Electrostatic ion trap	5
Borosilicate	10	Flux line lattice	5
Electrical transport properties	10	H_2	5
$NdBa_2Cu_3O_x$	10	HgCdTe	5
Thermomagnetic histories	10	High temperature optical Microscopy	5
YNi_2B_2C	10	$Li_2B_4O_7$	5
Conductivity	9	Lorentz force	5
Lithium zinc silicate	9	Measurement	5
Magnetoresistance	9	Metal seals	5
Microstructures	9	Multilayers	5
Superconductors	9	Oxygen diffusion	5
Synthetic crystals	9	Pd	5
Films	8	Pseudo-binary phase diagrams	5
Morphology	8	Silver nitrate	5
Resistivity behaviour	8	SiO_x	5
Si (111)	8	Structural properties	5
Transmission recovery	8	Structural correlation	5
Water Cooled Silicon	8	Trapping	5
Ion implantation	7	$YBa_2Cu_3O_7$-d/$La_{1-x}Pb_xMnO_3$	5

research such as crystals (192), thin films (173), miscellaneous domains (171), glasses and ceramics (102) and instrumentation (66). The highest number of publications (80) was produced in 2006. The average number of publications per year was 33.52. The study of activity index in various domains in different three year blocks shows that the maximum emphasis was given to domain crystals followed by miscellaneous domains in the first block (1986-1988) while the emphasis shifted to miscellaneous domains followed by crystals in the second block (1989-1991). During the third block (1992-1994) the stress was laid on thin films followed by crystals. In the fourth block (1995-1997) the importance was given to crystals followed by thin films and in the fifth block (1998-2000) interest was shifted to Instrumentation followed by Crystals and the emphasis was on Glasses and Ceramics in sixth (2001-2003) and seventh (2004-2006) blocks. Major channel of communication used by the scientists of TPPED was conferences during this period. The collaboration trend among the scientists

towards multi-authored papers is indicative of the highly specialised areas of scientific work that they were engaged in. The publication behaviour of scientists shows that they were highly selective in publishing their research results in highly specialised journals. It would be quite interesting to study other qualitative indicators based on citations, participation in international meetings, academic qualifications and awards received by these scientists.

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